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SCINTILLATION AND WEATHER FORECASTING.

"Twinkle, twinkle little star,
How I wonder what you are,
Up above the world so high,
Like a diamond in the sky."

WE are not prepared to show that the above quotation contains any indication of the author's scientific knowledge, but we could not bring ourselves to entitle this paper "Twinkling and Weather Forecasting," or else something besides the stars would have twinkled; on the other hand, the title we have chosen might *per se* have frightened away some whom we wish to read the following pages. Hence it was that we brought the above quotation to our rescue.

One other prefatory remark, viz., that the following pages are suggested by, founded upon, and condensed from, papers in the Belgian Meteorological Journal, *Ciel et Terre* (which we have often commended to our readers), and especially from the article "*La Scintillation des étoiles dans ses rapports avec les phénomènes météorologiques*" in which M. Montigny has been so kind and beneficent as to epitomise the result of his work upon the subject during the last quarter of a century.

In the first place we may mention that the twinkling of the stars (it will be remembered that the planets do not twinkle) has been skipped by a host of writers upon astronomy. It is useless to give a list of the works which omit all reference to it, and we therefore reproduce merely the short chapter in which Arago epitomizes his (we believe the first) thorough discussion of the subject.

ON SCINTILLATION.*

In the case of a person observing the stars with the naked eye, scintillation consists in rapid variations of brightness. These variations are often accompanied with changes of colour, and with alterations in the apparent diameters of the stars, or in the lengths of the diverging rays, which appear to dart from their centres in different directions. Scintillation in telescopes is accompanied with peculiar features. This phenomenon arises from the peculiar properties possessed by the constituent rays of light, of moving with different

* Popular Astronomy—Smyth and Grant's translation, Vol. I. (1855), p. 135.

velocities through the strata of the atmosphere, and of producing what is called interferences. We have devoted an entire Notice to the explanation of this curious fact, which has occupied the attention of the greater number of astronomers. It would be too long for insertion here ; and we think it useless to analyse its contents. It will suffice to state that the rapid changes of brightness and colour which the stars exhibit, are connected in the present day with the known laws of physics, and especially with those of luminous interferences. The more or less vague explanations of scintillation given by different astronomers are inadmissible ; they do not show why the planets, for example, do not scintillate ; why certain stars scintillate less than others ; why the purity of the sky and the low temperature of the nights add to the beauty of the phenomenon.

The first to make systematic observations on the amount of scintillation was Professor C. Dufour of Morges, on the Lake of Geneva ; he was followed very shortly afterwards by M. Montigny, of Brussels, and we think that it is within the mark to say that they two have done more towards elucidating the subject than all the rest of the world before or since. The former is quoted in the *Royal Society Catalogue* as the author of three papers on the subject, and the latter as author of eight, prior to 1873 when the last catalogue closes.

Professor Dufour began by trying several forms of scintillometer (twinkle measurer) which had been suggested by Arago and by others, but as he was not satisfied with any of them, he started a system of record with the naked eye, on an estimated scale with 0 for no scintillation, and 10 for the maximum. During about three years 1853–6 he did not lose a single evening when the stars were visible, and thus he amassed more than 13,000 records. The discussion of these observations led to the following conclusions :

(1) Red stars scintillate less than white ones.

(2) Except close to the horizon ; the scintillation is proportional to the product of the thickness of atmosphere traversed by the ray of light, multiplied into the astronomical refraction due to the altitude of the star.

(3) Besides the variation due to colour, there are differences which seem to be due to some property of the stars themselves.

Professor Dufour pointed out that the second conclusion justified the formation of a table whereby the scintillation of any star at any altitude might be converted into the equivalent for any uniform altitude, such as for example, that of 60° of zenith distance.

M. Montigny at an early date designed an apparatus which brings the rapid twinkling within the scope of easy and accurate measurement. We must refer our readers for the full description and necessary engravings to some of M. Montigny's earlier papers in *Ciel et Terre*—confining ourselves to some stray remarks which even

if not strictly accurate may still afford hints respecting the method. Cost is often a great obstacle to scientific progress, and therefore, heretical though it may be, we take it up first. M. Montigny tells us nothing about it. He says that he uses a 3 inch achromatic—and that is at any rate not a very serious item—it is perhaps not very far from the sized telescope most usually possessed by meteorological observers. His scintillometer, unless we mistake, can easily be so constructed as to become virtually merely an extra eye piece (just like a position micrometer) to such a telescope.* And when the workmen get used to making them we think that from £3 to £5 would probably cover the cost. As to the general principle of the instrument, we are irreverent enough to say that it is a combination of the whirling of a burning stick with that of the trick of rendering a coin visible by pouring water into the basin containing it—the image of the star taking the part of the burning stick, and a rapidly revolving inclined disc of plate glass, that of the water in the basin. The ray of light on its passage from the object-glass to the eye-piece has to traverse an oblique disc of glass $\frac{1}{4}$ of an inch thick, which disc can be made to revolve at any desired velocity, the bending of the ray of light in its passage through the plate glass causes the image of the star to become a disc, and this is only perfect when the rotation of the disc is exactly equal to the frequency of the scintillation.

We have already shown that Professor Dufour considered that there were what may be called personal characteristics attached to certain stars. M. Montigny early applied his ingenious appartus to the investigation of this subject. He selected 41 principal stars, grouped them according to the classification of P. Secchi which was wholly based upon the character of their spectra, and found that the rapidity of the scintillation followed almost precisely the spectroscopic classification—being slowest with stars whose spectra show many lines, and fastest with those whose spectra show only a few principal bands.

The regular observations made at Brussels by M. Montigny date back to 1870, and this series of 14 years forms the basis of the paper the title of which we have already quoted. In it M. Montigny begins by explaining that the indications given by the scintillometer may be divided into three classes.

(1) The intensity of scintillation. This is the most important indication, it gives the number of changes of colour exhibited by the scintillation of the star in a second of time reduced (as already explained) from the observed value to its equivalent at the fixed zenith distance of 60°; we do not see that the author states the average or the extreme rapidity of this scintillation, but from various

* Of course we are not suggesting that position micrometers are usual accompaniments of 3-inch telescopes—we quote them only as fairly equivalent to, though much more costly than, the scintillometer.

parts of his paper we believe that it may be for a minimum, 20 times a second, for the average 75 times, and during a violent tempest, as great as 233 times in a second.

(2) The various characters of the image produced by the scintillometer. This unfortunately can only be reduced to number in as far as the breadth of the image is concerned—but this is a very important feature, for M. Montigny says that he has long observed that the more the image broadens at the approach of rain the longer will the rain last. The circular image which in fine weather is narrow, perfectly regular and sharply edged, presents on the approach of rain thin filaments breaking off from its edges; the next day the image has become broader, and more irregular, its edge being hazy, undulated or even fringed when rain has begun, and dotted or beaded when a cyclone is near. These progressive changes are a positive indication of approaching disturbances.

(3) The colours which are shown to predominate. These seem to be constant for the same star.

The author then proceeds to epitomize the results obtained on upwards of 1,700 evenings, 1870–84. He divides these into 11 groups, and we give as briefly as possible the results he arrives at respecting each. He states that the influence of rain is so great that he discusses it first.

(1) *Intensity of Scintillation according to Seasons.* 1870-84.

	Spring	Summer	Autumn	Winter	Mean
Under the influence of dry weather	58	44	59	71	58
,, ,, rain ,,	78	68	82	103	83
Mean values	70	62	76	93	75
Excess "during rain" over "dry weather"	20	24	23	32	25
,, ,, ,, ,, ,, expressed as per cent of "dry weather"	35	55	39	45	43

M. Montigny contents himself with remarking that in all seasons the scintillation is notably increased during rainy periods, and that this intensity is even more marked in winter than in summer. We are inclined to think that M. Montigny has here fallen into error. At the bottom of his table we have added two lines; the first gives the excess in wet weather, expressed in scintillations, and is doubtless the series of figures which led him to the above conclusion; but the second line gives the ratio of scintillation in dry, and in wet weather, whence it will be seen that though the excess in the number of scintillations is greatest in wet weather in winter, the excess is not relatively so great as in other seasons: probably additional observations will show that the influence of rain is equal at all seasons.

(2) *Influence of the number of rainy days.*

On classifying the evenings of great and of little scintillation, we find that the former, with a mean scintillation frequency of 133, were followed by 86 per cent of wet days, the latter of 31, by only 45 per cent.

(3) *Influence of the approach of rain.*

Scintillation notably increases on the approach, and decreases on the cessation, of rain.

(4). *Influence of the sequence of wet days.*

Scintillation is much greater when there are three successive wet days, *i.e.*, the day of observation and the two following days; and somewhat less so when the day of observation is between two wet days. The average is 80 when it rains on the day of observation and on the following day, but only 66 when the rain follows on the two subsequent days.

(5). *Influence of cyclones.*

Kaemtz has already remarked that scintillation is excessive during times of atmospheric disturbance. M. Montigny states that his researches fully confirm this, and he gives extremely high rates of scintillation (211 and 233) as having occurred during the storms of February 26, 1876, and October 24, 1882. He states that the scintillation gradually increases as the depression approaches, and decreases as it passes away.

(6). *Influence of the approach of rain on the altitude at which the changes of colour in a scintillating star cease to be perceptible.*

According to Humboldt, the arrival of the rainy season in the tropics is announced many days in advance by the scintillation of the stars at high altitudes, although in those regions scintillation is unusual. At Brussels changes of colour are perceptible at greater altitudes before rain than before dry weather.

(7). *Influence of the humidity of the air.*

In order to detect this, it is necessary to avoid instances influenced by approaching rain; this M. Montigny has attempted to do, and he finds that *in dry weather* the scintillation increases with increasing humidity.

(8). *Influence of fog.*

In dry weather scintillation increases when fog will be formed in the evening after observation, but it does not increase if fog will follow the next day or even the next morning. Probably, in the former case, the formation of fog particles has already commenced in the higher regions when the observation is made.

(9). *Influence of snow.*

While the air is full of snow there are sometimes rifts through

which the stars shine. It is found that they then scintillate more than usual, and more than is due to temperature alone.

(10). *Influence of temperature.*

In order to study this, it is necessary to select periods free from the influence of rain. Having done so, the following values were obtained :—

Limits of Temperatnre.	Mean Temperature.	Intensity of Scintillation.	M.T. × I. of S.
77° to 68°	70°·3	39	2742
68 ,, 59	63 ·5	44	2794
59 ,, 50	52 ·3	55	2876
50 ,, 41	44 ·6	60	2676
41 ,, 32	37 ·6	75	2820
32 ,, 23	24 ·8	99	2455
23 ,, 14	18 ·1	103	1864

To M. Montigny's table we have added a column which conclusively proves his statement. The figures are the result of multiplying together the mean temperature and the scintillation; if the one increases as the other decreases the resultant should be nearly constant and (except for the values below freezing point) this proves remarkably the case.

M. Montigny himself seems to have scarcely realized the extreme closeness of the agreement for he does not speak so confidently respecting it, as respecting other conclusions for which evidence of equal strength is not given.

(11). *Influence of wind.*

No numerical values are given under this head, but it is pointed out that the influence of cyclones has already been mentioned as well as that of rain, humidity, and temperature. It is somewhat difficult to eliminate the influence of wind from all the foregoing, but M. Montigny mentions one fact worthy of note. When, on a windy evening, the scintillation of many stars is observed, the scintillation is generally found to be greatest in the path of the wind, *i.e.*, in the direction whence it comes and whither it goes.

M. Montigny concludes with the following paragraphs :—

"From the foregoing remarks it appears that it is the amount of water in the atmosphere which chiefly regulates the frequency of scintillation and modifies its characteristics according as this water is dissolved in vapour, falls as rain, or floats as snow.

"The whole of the facts which I have just epitomized respecting the relations between scintillation and atmospheric conditions form the basis of the application of the scintillometer to *weather forecasting.*

"Let me add that this beautiful phenomenon if continuously and carefully studied will be equally useful to Meteorology itself, by the information which it will afford respecting the influence of the earth's atmosphere on stellar light."

EXTRAORDINARY FALL OF RAIN AND SNOW IN VIENNA, MAY 15, 1885.

We begin this note by reminding our readers that the rainfall of Vienna on the average of 30 years, is (rather less than that of London) 23·43 inches. This will enable them to realize how exceptional must be a fall of very nearly *six inches* in one day.

It is a common fallacy to consider that England has a monoply of bad weather. We reproduce from the *Zeitschrift d. Oester. Gesell. f. Met.* for June, Dr. Hann's note upon May 15th, as a specimen of how uncomfortable Vienna weather can be.

The evening of May 14th, was dark and showery, with heavy black clouds in S.E., temp. at 9 p.m., 49°. In the morning of the 15th (about 6 a.m.) the wind backed to E. and E.N.E.. and the rain increased. The barometer continued to fall till nearly noon, the temperature remaining about 50°, and rain falling at the rate of about a tenth of-an-inch an hour. About noon the wind backed through N. to W. and it began to blow a gale, the mean hourly velocity for the following 18 hours being 42 miles, and in several hours exceeding 50 miles—the rain (as will be seen by the following table) not only continued but increased, while the temperature fell nearly to freezing point, and about 6 p.m. the rain took the form of a driving mixture of rain and wet snow, which finally ceased almost precisely 24 hours after it had begun, and yielded the extraordinary total of 5·99 inches.

Dr. Hann says "Es war das gräulichste Unwetter, das man sich denken kann"* and the instrumental records quite confirm his opinion. Six men were frozen to death in the suburbs, and a house fell, partly from the force of the gale, and partly from the weight of snow on the roof, while the damage to trees, crops and cattle was excessive.

Heavy Rainfall at the Centralanstalt, Hohe Warte, Vienna, May 15-16th, 1885.

Hour ending	Rain. in.	Hour ending	Rain. in.	Hour. ending	Rain. in.	Hour. ending	Rain. in.
7 a.m.	·02	1 p.m.	·06	7 p.m.	·36	1 a.m.	·52
8 ,,	·06	2 ,,	·09	8 ,,	·25	2 ,,	·30
9 ,,	·18	3 ,,	·15	9 ,,	·39	3 ,,	·53
10 ,,	·19	4 ,,	·12	10 ,,	·35	4 ,,	·46
11 ,,	·15	5 ,,	·26	11 ,,	·44	5 ,,	·16
Noon	·12	6 ,,	·43	midn't.	·30	6 ,	·10
Totals...	.72		1·11		2·09		2·07

The results of another gauge are given, and therefore treating the above record as that of Gauge A, we give the two records added up for corresponding periods.

*It was the most abominably bad weather that can be imagined.

	Centranstalt. Gauge A. in.	Centranstalt. Gauge B. in.	Agricultural School. in.
May 15th, 0 to 7 a.m.	·02	·06	
,, ,, 7 a.m. to 2 p.m.	·85	·70	
,, ,, 2 p.m. to 9 p.m.	1·96	1·82	
,, ,, 9 p.m. to 6 a.m. (16th)	3·16	2·96	
Gross Total	5·99	5·54	5·85

The gauge at the new Astronomical Observatory was allowed to run over, and therefore became useless.

Dr. Hann remarks that the greatest fall previously recorded was 4·10 in. on the 28th–29th of July, 1882, and that it far exceeded all previous records, the greatest previously having been 2·71 in. on June 30th, 1864, and 2·83 in. on May 16th, 1851

The fact which appears to us the most noteworthy is, that this excessive fall was the product of what must (in spite of its unusual amount) be designated as ordinary rain, *i.e.*, it was not one of those torrential downpours which occur during thunderstorms, and which are variously described as "waterspout," "bursting of a cloud," and so on. It was a *very remarkably prolonged* ordinary heavy rain.

ATLANTIC TIDES AS STORM WARNINGS.

To the Editor of the Meteorological Magazine.

SIR,—I cannot agree with Dr. Muirhead's deduction that the action of the tidal wave, referred to in my letter, is due to the suction of the waters *within* the cyclone area from diminished aerial pressure.

Were this the cause the tide level, on the approach of a cyclone, would rather diminish than increase by the very law which raised the waters within the disturbed area, and an exactly opposite result would be observed until the cyclone was at hand.

The acceleration of the tidal crest in this instance, however, occurs *far in advance of* the mercurial fall, and therefore the Hebrideans, although possessed of good barometers in some places, wisely prefer the warning of tidal level as being certain, to that of the barometer, which, affected by many variable influences, is frequently both slow and deceptive in its action.

The cause appears to me to be due to the increased pressure on the flow and against the ebb of the tide wave, assisted by the flow of the gulf stream, for a considerable distance in advance of an an approaching cyclone, the measure of which, will indicate with certainty, the nature, and to some extent the course, of the disturbance to follow.

Yours faithfully,

G. WOULFE BRENAN, C.E.

Oban, Argyllshire.

ON RELATIVE HUMIDITY AND THE DRYNESS OF THE AIR.

To the Editor of the Meteorological Magazine.

SIR,—Mr. Strachan's letter on the above subject in your June Magazine, will not tend to restore confidence as to the methods adopted for obtaining the relative humidity of the air. The conclusions which I have arrived at are based upon the results of numerous observations and experiments which Professor Tyndall has somewhere called "popping the question" to nature herself. Many of these observations have been witnessed by yourself and others.

I must, therefore, beg to remind Mr. Strachan, that these conclusions are not to be swept away by his preference for one hygrometer or the other, or by any speculation as to the differences which may exist between the temperatures of the inside and outside surfaces of a vessel containing water, the thickness of the sides being about ·01 of an inch. This question is not new to me as will be seen by a reference to my papers on evaporation;* it is a question of which no accurate solution seems possible, but experiment tells me, that the difference is so small as to escape observation. This result is not surprising when it is considered that the specific heat of the water, volume for volume, is more than 3,000 times greater than that of the air by which it is surrounded.

G. DINES.

Walton-on-Thames, July, 1885.

SOLAR HALOS.

To the Editor of the Meteorological Magazine.

DEAR SIR,—On the 22nd of June, about mid-day, I observed a halo of perhaps an unusual type. Two bands were visible, but neither of them was very distinct; the inner one was red, and the outer a blue or violet. It was probably visible for about half-an-hour. I cannot find any instance of one similar to it in my previous records of observation on halos. I may add that I saw two distinct parhelia, and the upper arc of a solar halo at 5 p.m. on June 5th.

Your's truly,

R. MONTAGUE MERCER.

Rodmersham House, near Sittingbourne, July 9th, 1885.

ATMOSPHERIC ELECTRICITY.

PROFESSOR PALMIERI, of the Vesuvian Observatory, has recently published some observations of interest on atmospheric electricity. In clear weather the atmospheric electricity is usually positive, if

* See "Proceedings of the Meteorological Society," Vol. V. (1870) page 205 and 300.

negative a downfall of rain, &c., may be inferred to be going on at some little distance. There is a maximum of atmospheric electricity at 9 a.m., another soon after sunset, which often continues during a great part of the night. A minimum takes place before daybreak, and another in the afternoon. This periodicity is, however, disturbed by atmospheric movements. When the maxima are very pronounced, cloudy weather often follows. If the sky becomes overcast the electric indications grow stronger, and if at the time of the evening maximum the relative moisture increases with a heavy dew, maxima of special duration and intensity may be expected. The assumption that atmospheric electricity becomes stronger with altitude is not borne out by the Vesuvian obervations. Lower potentials are generally observed on hot summer days; in spring and autumn the indications are stronger; in winter they are uncertain. On cloudy days the potential is less intense, but positive; during rain the potential increases. A rain zone is positive but surrounded by a negative zone, which again is surrounded by a zone of positive electricity.* According to Palmieri, there is no thunder and lightning without rain.—*English Mechanic, May* 29th, 1885.

ROYAL METEOROLOGICAL SOCIETY.

THE concluding meeting of this Society for the present session was held on Wednesday, 17th of June, at the Institution of Civil Engineers, 25, Great George Street: Mr. R. H. Scott, F.R.S., President, in the chair.

Lieut. A. Leeper, R.N., was elected a Fellow of the Society.

The following papers were read :—

(1). "A few Meteorological Observations made on a voyage up the Nile in February and March, 1885," by Dr. W. Marcet, F.R.S. The author, on a voyage up the Nile from Cairo to Assouan, made a series of meteorological observations, and in the present paper gives the result of those relating mainly to nocturnal radiation and to the temperature of the water of the Nile.

(2). "The Mean Direction of Cirrus Clouds over Europe," by Dr. H. H. Hildebrandsson, Hon. Mem. R. Met. Soc. The author has collected a number of observations on the movements of cirrus clouds over various parts of Europe, and after discussing them has arrived at the following results :—(1) The mean direction at all stations lies between south-west and north-west; (2) in winter the cirri come from a more northerly direction, and in summer from a more southerly; (3) in winter the northerly component is greater on the Baltic and the north coast of the Mediterranean; (4) the mean directions of the upper currents nearly coincide with the mean

* Just what Andrew Crosse said half a century since, and not only said, but observed the phenomena, and offered an explanation. See *Memorials of Andrew Crosse*, 1857, 12mo., page 134.—*Ed. Met. Mag.*

tracks of storm-centres; (5) the upper currents of the atmosphere tend in general to flow away from those areas in which a barometrical depression exists at the earth's surface towards those in which there is an elevation of pressure.

(3). "On the Influence of Accumulations of Snow on Climate," by Dr. A. Woeikoff, Hon. Mem. R. Met. Soc.

(4). "Note on the Weather of January, 1881," by Mr. C. Harding, F.R. Met. Soc. It will be remembered that the weather of January, 1881, was remarkable for the prolonged and exceptionally severe frost, the heavy gale of the 18th and 19th, and the snow-storms. The author has prepared isobaric charts for the North Atlantic and the adjacent continents for January, 1881, and compared them with similar charts for January in other years. He shows that the severe weather in 1881 was due to a reversal of the normal conditions, the atmospheric pressure being high in the north and low in the south.

(5). "Results of Meteorological Observations made in the Solomon Group, 1882-84," by Lieut. A. Leeper, R.N.

(6). "Graphic Hygrometrical Table," by Mr. D. Cunningham, M. Inst. C.E., F.R. Met. Soc.

CURIOUS RECORD OF A HAIL STORM.

In a very old farmhouse at Biscot, near Luton, Bedfordshire, the following inscription is engraved on an old stone chimney-piece:—"There was hailstones fell July 23, of this bigness and likeness, 1666. T. T." One "likeness" shows a circular stone, half an inch in diameter, another is oval, and measures an inch in length. W. G. S.—*Gardener's Chronicle*, May 9th, 1885.

INTERIOR TEMPERATURE OF THE EARTH.

The German Government is having a deep shaft sunk near Schladebach [between Merseburg and Leipzig], with the object of obtaining various kinds of scientific information, and especially trustworthy *data* concerning the rate of increase of the earth's temperature as we descend into the interior. The excavation is being carried on by a diamond-tipped borer driven by water. As far back as the beginning of this year the shaft had reached the depth of 1,392 mètres [4,567 ft.], which is believed to be the lowest depth yet reached by boring. The temperature at successive stages is ascertained by an ingenious instrument which serves as a special thermometer, the principle of construction being the fact that as the heat increases, the mercury will expand so as to flow over the lip of a sufficiently short open tube in greater and greater quantities. The measurement of the differences of those overflows will give the rate of increase of the temperature. It has been ascertained that the temperature at the depth of 1,392 mètres [4,567 ft. or $\frac{7}{8}$ of a mile] was 49° Centigrade, or 120° Fahrenheit. If the temperature increases regularly at this rate, the boiling point of water ought to be reached at a depth of 3,000 mètres [9,843 ft. or nearly 2 miles], and at 75 kilomètres [47 miles], we should find the heat at which platinum melts. This would go to show that the thickness of the earth's crust cannot be more than about one-ninetieth of its radius.—*The Times.*

CLIMATOLOGICAL TABLE FOR THE BRITISH EMPIRE, DECEMBER, 1884.

STATIONS. (*Those in italics are South of the Equator.*)	Absolute. Maximum. Temp.	Date.	Minimum. Temp.	Date.	Average. Max.	Min.	Dew Point.	Humidity.	Absolute. Max. in Sun.	Min. on Grass.	TotalRain. Depth.	Days.	Aver. Cloud.
	°		°		°	°	°	0–100	°	°	inches		0–10
England, London	55·7	8	28·5	31	45·9	36·6	37·1	85	66·7	22·2	2·57	17	7·3
Malta	66·2	10*a*	44·6	23	61·9	52·8	50·2	83	109·4	37·9	4·87	15	4·9
Mauritius	86·0	19	66·4	5	83·1	71·2	65·6	71	136·4	57·5	1·56	13	5·4
Calcutta	78·9	28	52·7	10	76·4	56·5	55·6	73	133·2	37·6	·00	0	1·6
Bombay	88·0	10*b*	66·6	23*c*	83·4	68·9	63·5	67	142·1	53·4	1·14	2	2·9
Ceylon, Colombo	89·0	4	69·1	27	85·2	72·9	69·1	71	150·0	63·0	14·30	13	6·0
Melbourne	89·3	31	43·3	1	72·5	52·5	49·0	66	150·6	36·9	3·05	15	6·2
Adelaide	97·6	29	47·9	23	77·1	57·1	47·1	49	160·7	32·5	·96	13	5·1
Wellington	70·0	2	44·3	13	64·2	53·3	.	...	145.0	40·0	12·46	23	...
Auckland	75·5	16	51·0	3	68·6	55·9	53·1	72	144·0	43·0	5·66	19	6·0
Kingston	89·5	1	63·3	29	86·6	67·9	68·5	79	...	58·8	·00	0	2·8
Barbados	80·0	1*d*	69·0	23*e*	78·0	70·0	68·8	80	140·0	...	4·07	10	5·0
Toronto	50·6	31	—13·3	19	31·7	18·8	24·5	83	94·0	—14·0	3·26	17	7·7
New Brunswick, Fredericton	48·8	30	—28·5	28	28·1	8·0	19·2	88	...	...	6·51	17	5·5
Manitoba, Winnipeg	41·3	2	—43·6	23	4.6	—11·5	5·0	94	...	...	1·11	8	5·5
British Columbia, Victoria	54·0	1	8·0	29	...	...	...	...	...	...	1·95	11	...

a And 13. *b* And 18. *c* And 29. *d* And 11, 12. *e* And 24, 25.

REMARKS, DECEMBER, 1884.

MALTA.—Mean temp. 56°·5; mean hourly velocity of wind 11 miles; sea temp. fell from 65° to 62°. TSS on 2 days, H on 22nd and 24th. J. SCOLES.

Mauritius.—Rainfall 3·79 in. and temp. 1°·0 below average; prevailing direction of wind E. and E.N.E. Scarcely any unusual colorations of sky. C MELDRUM, F.R.S.

COLOMBO.—TSS on 3 days, L on 8th and 30th. F. C. H. CLARKE, Major, R.A.

Melbourne.—Mean temp. 2°·2 and temp. of dew point 1°·2 below their respective averages, rainfall 0·69 in. above average, humidity and amount of cloud both slightly above average. Prevailing winds W., S. and S.W. strong on 10 days, heavy squalls on 3 days. TS with H on 7th, L on 14th. R. L. J. ELLERY, F.R.S.

Adelaide.—Remarkable for low pressure, coolness, and the force of the wind. Mean pressure nearly ·10 in. below the average of the previous 28 years, and the lowest on record. The mean temp. (67°·1) was nearly 4° less than the average and the lowest on record since 1856; temp. reached 90° on only 4 days, the average number being 9. The total horizontal motion of the wind, 10,990 miles, was far in excess of any previous record; but notwithstanding the unusually stormy weather, the rainfall was only 0·12 in excess of the mean for the previous 27 years. C. TODD.

Wellington.—Showery weather up to 12th. heavy R being recorded on 5th, 6th and 11th; tolerably fine then until the 23rd; remainder of the month showery, with heavy R, 3·48 in., the max. for the month on the night of 28th. Total rainfall 8·81 in. above the average, number of wet days more than twice the average, mean temp. 2°·5, and pressure slightly, below average. R. B. GORE.

Auckland.—The early portion of the month was unsettled and showery; from 9th to 19th, mostly fine and pleasant, the close of the month variable and showery with occasional heavy TSS. Rainfall greatly in excess. T. F. CHEESEMAN.

KINGSTON.—The rainfall for the month over the whole Island, was less than half the average, rivers giving out, the Llandovery never known to be dry before this year being dry for the 4th time in 1884. MAXWELL HALL.

BARBADOS.—Mean temp. 74°, 1°·1, and rainfall 36 per cent. below the average for 25 years. R. BOWIE WALCOTT.

SUPPLEMENTARY TABLE OF RAINFALL, JUNE, 1885.

[For the Counties, Latitudes, and Longitudes of most of these Stations, see *Met. Mag.*, Vol. XIV., pp. 10 & 11.]

Div.	STATION.	Total Rain.	Div.	STATION.	Total Rain.
		in.			in.
II.	Dorking, Abinger	2·19	XI.	Rhayader, Nantgwillt..	2·40
,,	Margate, Birchington...	·84	,,	Carno, Tybrith	2·23
,,	Littlehampton	1·67	,,	Corwen, Rhug	1·72
,,	Hailsham	·72	,,	Port Madoc	2·98
,,	I. of W., St. Lawrence.	2·51	,,	I. of Man, Douglas	1·70
,,	Alton, Ashdell.....	2·02	XII.	Stoneykirk, Ardwell Ho.	·67
III.	Winslow, Addington ...	1·91	,,	Melrose, Abbey Gate...	·74
,,	Oxford, Magdalen Col...	1·67	XIII.	N. Esk Res. [Penicuick]	1·10
,,	Northampton	1 72	XIV.	Ayr, Cassillis House ...	...
,,	Cambridge, Beech Ho...	2·75	,,	Glasgow, Queen's Park.	·80
,,	Wisbech, Bank House..	1·83	XV.	Islay, Gruinart School..	1·94
IV.	Southend	·80	XVI.	St. Andrews, Newton Bk	·72
,,	Harlow, Sheering	1·82	,,	Balquhidder, Stronvar..	1·99
,,	Rendlesham Hall	·85	,,	Dunkeld, Inver Braan..	·68
,,	Diss	·72	,,	Dalnaspidal H.R.S. ...	1·46
,,	Swaffham	1·30	XVII.	Keith H.R.S.	1·48
V.	Salisbury, Alderbury...	1·93	,,	Forres H.R.S.	1·68
,,	Warminster	1·21	XVIII.	Strome Ferry H.R.S....	4·14
,,	Calne, Compton Bassett	1·63	,,	Lochbroom	2·91
,,	Ashburton, Holne Vic..	2·06	,,	Tain, Springfield.....	1·32
,,	Holsworthy, Clawton...	3·04	,,	Loch Shiel, Glenaladale	5·99
,,	Hatherleigh, Winsford.	3·63	,,	Invergarry	2 45
,,	Lynmouth, Glenthorne.	2·25	XIX.	Lairg H.R.S.	2·16
,,	Probus, Lamellyn	2·60	,,	Forsinard H.R.S.	2·30
,,	Wincanton, Stowell Rec.	1·31	,,	Watten H.R.S.	2·55
,,	Wells, Westbury.....	1·13	XX.	Dunmanway, Coolkelure	·65
VI.	Bristol, Clifton	1·73	,,	Fermoy, Gas Works ...	1·73
,,	Ross	2·33	,,	Tralee, Castlemorris ...	1·46
,,	Wem, Sansaw Hall.....	...	,,	Tipperary, Henry Street	·11
,,	Cheadle, The Heath Ho.	3·54	,,	Newcastle West	...
,,	Worcester, Diglis Lock	3·63	,,	Miltown Malbay.....	1·50
,,	Coventry, Coundon	2·38	,,	Corofin	...
VII.	Melton, Coston	1·85	XXI.	Carlow, Browne's Hill..	1·20
,,	Ketton Hall [Stamford]	2·67	,,	Navan, Balrath	1·01
,,	Horncastle, Bucknall ...	2·24	,,	Mullingar, Belvedere ...	·86
,,	Mansfield, St. John's St.	3·71	,,	Athlone, Twyford	·89
VIII.	Macclesfield, The Park.	3·33	XXII.	Galway, Queen's Col....	·50
,,	Walton-on-the-Hill.....	2·18	,,	Clifden, Kylemore	1·83
,,	Lancaster, South Road.	2·04	,,	Crossmolina, Enniscoe..	·54
,,	Broughton-in-Furness ..	...	,,	Carrick-on-Shannon ...	·56
IX.	Wakefield, Stanley Vic.	2·45	XXIII.	Dowra	...
,,	Ripon, Mickley	3·01	,,	Rockcorry.....	...
,,	Scarborough.....	2·84	,,	Warrenpoint	·93
,,	East Layton [Darlington]	2·04	,,	Newtownards	...
,,	Middleton, Mickleton ..	1·59	,,	Belfast, New Barnsley..	1·15
X.	Haltwhistle, Unthank..	1·24	,,	Cushendun	·85
,,	Shap, Copy Hill	1·43	,,	Bushmills	1·11
XI.	Llanfrechfa Grange	2·84	,,	Stewartstown	.71
,,	Llandovery	3·19	,,	Buncrana	·84
,,	Castle Malgwyn	1·92			

JUNE, 1885.

Div.		STATIONS. [The Roman numerals denote the division of the Annual Tables to which each station belongs.]	RAINFALL. Total Fall.	Difference from average 1870–9	Greatest Fall in 24 hours. Dpth	Date.	Days on which ·01 or more fell.	TEMPERATURE. Max Deg.	Date	Min. Deg	Date	No. of Nights below 32°. In shade.	On grass.
			inches	inches.	in.								
I.	ENGLAND.	London (Camden Square) ...	1·99	— ·68	·79	8	11	84·7	4	41·4	11	0	0
II.		Maidstone (Hunton Court)...	1·21	— ·86	·36	8	8	...	...	...	...	...	...
,,		Strathfield Turgiss	1·79	— ·31	·48	16	9	83·1	4	36·4	11	0	0
III.		Hitchin	2·63	+ ·50	1·44	8	11	75·0	4	35·0	10	0	...
,,		Banbury	2·30	— ·14	·77	8	11	82·0	4	37·0	11	0	...
IV.		Bury St. Edmunds (Culford)	·93	— 1·34	·33	8	11	88·0	3	33·0	10*e*	0	...
,,		Norwich (Cossey)	·96	— 1·26	·35	8	8	83·5	4	38·0	11*f*	0	...
V.		Weymouth(LangtonHerring)	1·46	...	·41	5	9	...	...	...	...	...	...
,,		Barnstaple.....	3·62	+ ·90	1·21	23	10	83·5	5	45·0	1	0	...
,,		Bodmin	2·70	— ·51	1·32	23	11	72·0	13*b*	45·0	10	0	0
VI.		Stroud (Upfield)	1·95	— ·43	·37	6 & 8	11	81·0	4	44·0	10	0	...
,,		ChurchStretton(Woolstaston)	3·81	+ ·94	·95	23	11	79·5	4	41·5	10	0	...
,,		Tenbury (Orleton)	2·79	+ ·05	·73	6	10	80·7	4	38·0	11*g*	0	0
VII.		Leicester	2·55	...	·84	6	11	84·5	4	39·2	11	0	4
,,		Boston	2·27	+ ·02	1·10	7	9	87·0	3	40·0	27	0	...
,,		Grimsby (Killingholme).....	3·44	+ 1·07	1·11	8	13	80·5	4	41·0	11	0	...
,,		Hesley Hall [Tickhill].....	2·79	...	·65	6 & 8	9	86·0	4	39·0	2*h*	0	...
VIII.		Manchester (Ardwick).....	3·96	+ ·80	·84	23	12	83·0	4	45·0	11*i*	0	...
IX.		Wetherby (Ribston Hall) ..	3·44	+ ·57	1·15	24	7	...	...	...	...	...	...
,,		Skipton (Arncliffe)	3·25	— ·57	·63	18	12	80·0	13	38·0	26	0	...
X.		North Shields	1·62	— ·41	·81	24	9	77·8	12	39·0	10	0	0
,,		Borrowdale (Seathwaite).....	6·15	— 1·66	2·28	18	13	73·7	28	38·5	26	0	...
XI.	WALES.	Cardiff (Ely).....	2·88	— ·18	·95	23	11	...	...	...	...	...	...
,,		Haverfordwest	2·50	— ·53	·60	8	10	73·0	13	40·0	1*j*	0	1
,,		Plinlimmon (Cwmsymlog) ...	3·14	...	·75	22	11	...	...	...	...	...	...
,,		Llandudno.....	·95	— 1·05	·32	6	8	74·0	3	45·2	10	0	...
XII.	SCOTLAND.	Cargen [Dumfries]	·92	— 2·25	·39	18	9	74·0	28	35·4	10	0	...
,,		Jedburgh (Sunnyside).....	·49	— 1·91	·13	28	8	75·0	13*c*	35·0	10*k*	0	...
XIV.		Douglas Castle (Newmains)	·68	— 2·33	...	...	...	...	...	...	...	...	...
XV.		Lochgilphead (Kilmory)	2·69	— 1·15	·75	3	13	...	...	...	...	...	...
,,		Oban (Craigvarren)	2·98	...	·62	18	17	69·5	28	41·5	10	0	...
,,		Mull (Quinish).....	3·49	...	·72	18	16	...	...	...	...	...	...
XVI.		Loch Leven Sluices	·80	— 1·97	·20	19*a*	6	...	...	...	...	...	...
,,		Arbroath	·85	— 1·76	·19	20	8	70·0	3	41·0	10	0	...
XVII.		Braemar	1·23	— 1·86	·49	28	12	71·0	28	32·1	9	0	...
,,		Aberdeen	1·07	...	·39	18	10	77·0	12	35·0	9	0	...
XVIII		Skye (Sligachan)	...	...	...	...	...	...	...	...	...	...	...
,,		Culloden	·80	— 1·45	...	...	...	74·0	27	36·0	10	0	3
XIX.		Dunrobin	1·94	...	·42	18	10	72·0	27	38·0	10	0	...
,,		Orkney (Sandwick)..... ...	2·50	+ ·70	·36	18*c*	21	61·4	5	39.5	26	0	4
XX.	IRELAND.	Cork (Blackrock)	1·19	— 2·36	·43	4	6	83·0	28	41·0	5	0	...
,,		Dromore Castle	1·56	...	·50	4	8	70·0	29	41·0	30	0	...
,,		Waterford (Brook Lodge) ...	1·51	...	·55	7	9	71·0	28	38·0	10	0	8
,,		Killaloe	1·58	..	·36	4	10	76·0	28	43·0	26*l*	0	...
XXI.		Portarlington	1·03	— 1·40	·31	7	10	73·5	12	40·0	25	0	...
,,		Dublin (FitzWilliam Square)	1·51	+ ·69	·50	7	8	73·3	3	40·9	10	0	0
XXII.		Ballinasloe	·73	— 2·46	·18	4	9	70·0	11*d*	37·0	6*m*	0	...
XXIII		Waringstown	·77	— 1·89	·15	4	12	83·0	7	35·0	9	0	
,,		Londonderry (Creggan Res.).	1·00	...	·19	2	14	...	...	...	...	...	...
,,		Omagh (Edenfel)	·78	— 2·27	·21	18	10	72·0	28	36·0	5*n*	0	3

a And 20. *b* And 14. *c* And 28. *d* And 12, 13 and 29. *e* And 27. *f* And 28. *g* And 2
h And 10. *i* And 26, 27. *j* And 2, 27. *k* And 26. *l* And 27. *m* And 28. *n* And 22.
+ Shows that the fall was above the average; — that it was below it.

METEOROLOGICAL NOTES ON JUNE.

ABBREVIATIONS.—Bar. for Barometer; Ther. for Thermometer; Max. for Maximum; Min for Minimum; T for Thunder; L for Lightning; T S for Thunderstorm; R for Rain; H for Hail S for Snow.

ENGLAND.

STRATHFIELD TURGISS.—The rains of the early part wonderfully improved the hay crop, which, however, was not heavy; cutting began on 15th. Corn crops and beans doing well; hops favourable and free from aphis. Common blue and meadow brown butterflies flying on 1st; dog rose in flower on 12th; honey-suckle on 18th.

BANBURY.—Mean temp. 57° 5. A favourable month, rains in the early part very useful; haymaking general at the end, in fine drying weather. L on 7th, 14th and 18th; high wind on 18th.

CULFORD.—A very dry month with some very hot days, followed by cold nights. Apple crop very blighted and thin.

LANGTON HERRING.—On the whole a fine month; haymaking during the last week under very favourable conditions; crop heavy. Dense fogs occurred on 5th, 6th and 7th, which with those of the last week in May, blighted the fruit trees to some extent. There were fogs on 19th, 22nd, and 23rd, also.

BODMIN.—Mean temp., 61°·3.

STROUD.—L in North at 9 p.m. on 7th.

WOOLSTASTON.—T and L on 7th.

ORLETON.—Very variable temp., with many bright days and cold nights; very warm till the 5th, then cloudy and rainy till the 11th, fine and warm again till the 15th, after which it was generally cold and stormy to the end of the month. Mean temp. about 0°·8 above the average of 24 years. Prevailing wind N.W. to N.E., frequently rough and cold. All vegetation late, but generally luxuriant. L and T on 7th, L on 13th.

KILLINGHOLME.—The beginning of the month was warm, ; heavy R followed and temp. fell; the nights were cold throughout, checking the growth of root crops; grass and corn crops looking well. Earthquake slightly heard and felt about 11 a.m. on 17th; distant T and L on night of 7th.

MANCHESTER.—On the whole a fine month, but temp. was, with some exceptions, rather chilly, especially at night. Vegetation, however, made great progress, and agricultural prospects are good.

SEATHWAITE.—A severe shock of earthquake was felt at 5·45 a.m. on the 30th.

WALES.

HAVERFORDWEST.—Up to the 13th, fine, warm, growing weather prevailed; a good deal of R fell between the 4th and 8th; after the 14th, temp. was greatly in defect, strong polar currents prevailing. This weather had a very injurious effect on the fruit trees, disappointing the early promise, blossom having been most abundant. The wind on 28th, 29th, and 30th was very violent, with sudden squalls, snapping the gooseberry and currant trees. T and L, with copious R, on the night of 4th. Mean temp. considerably below average; grass temp. on ten nights very low for June.

LLANDUDNO.—A month of bright, very dry weather; mean temp. nearly 2° below average, and the range, both diurnal and monthly, considerably below average; polar winds prevalent. Hay crop unprecedentedly light.

SCOTLAND.

CARGEN.—Notwithstanding more than an average amount of sunshine (240 hours against an average of 230 hours), the mean temp. of the month was 2°·1 below average; the atmosphere, however, was very dry. Vegetation very backward; profusion of blossom on all forest and fruit trees quite remarkable; pears and plums will be a failure as regards fruit.

JEDBURGH.—Though very dry, vegetation progressing greatly. Foliage has not been so luxuriant for many years. The apple and pear crops, which pro-

mised so well in May, have gone on well, and been little affected by caterpillar; the crop is now certain to be abundant. The leaf of the ash has been much behind that of the oak; the hawthorn has not, more than once or twice, for many years, been so luxuriant in this district. It is worth while remarking that the landrail has been little heard during the month in this district, where in former years its cry was almost constant. The mavis, which was thought to have been killed out by the severe winters two or three years ago, has been very plentiful; blackbirds, also, are exceptionally numerous. The gooseberry crop is light. Wind E. or N.E. on ten days.

OBAN.—Decidedly a cold June, with less than the usual sunshine, and frequent showery weather. Hay crop strong, but much requiring sunshine. Inland birds not so plentiful as last year, but wild flowers unusually large and attractive. Two slight shocks of earthquake were felt in this district, but not near Oban. Cloud fogs at sea level were very prevalent; that of the 27th being specially noteworthy, rising and falling on the hill side until finally by the cold N.E. wind in the upper, and S.W. in the lower sky, it was driven into a long stretch of sunlit white cloud of dazzling brilliancy. The phenomenon lasted all day.

QUINISH.—The 27th and 28th were hot days, but the month, as a whole was cold and showery. Vegetation unusually backward.

CULLODEN.—The month was only moderately warm. From 1st to 7th, and 9th to 19th, and then from 22nd to the close, the weather was very dry; crops and pasture land suffering.

IRELAND.

DROMORE.—A very fine month, with very strong N.E. winds at times.

KILLALOE.—Beautiful weather throughout; all that could be desired for early haymaking. Mean temp. 58°·9.

DUBLIN.—A dry, cool, generally fine month. Polar winds predominated, but much warm sunshine modified their searching character. All the rainfall occurred in a few heavy downpours. A striking feature of the month on several occasions was the luminous appearance of strands of cirrus cloud on the northern horizon late at night, and which was clearly due to reflected daylight. There was no sleet or H, nor did electrical disturbances occur near Dublin. An aurora borealis was seen on the night of the 9th; solor halos on 6th and 10th; fog on 1st and 7th. Mean temp. (54°·8) 1°·8 below the average; colder than any June for 20 years, except 1882, when the mean temperature was 54°·7. In 1869 and in 1879, the celebrated cold year, the mean temp. (54°·9) very closely approximated to that of June, 1885. Mean humidity 74; mean amount of cloud 5·1; prevailing winds N.E., N.W., W.S.W.

WARINGSTOWN.—Very dry but not warm.

EDENFEL.—Bright fresh and charming weather, excellent for haymaking, but much too dry for all other crops. Rainfall the smallest, except 1865, for 21 years. Frost on 3 nights, doing much damage to low-lying potatoe fields; this has not occurred here before within the above-named period.

ERRATA IN THE METEOROLOGICAL MAGAZINE 1884.

REGULAR TABLE.

Hunton Court, August,	*should be*	·91	Culloden, March, *should be* ...		1·37
Barnstaple, October,	,,	3·98	Edenfel, April,	,, ...	1·38
,, November	,,	2·98			

SUPPLEMENTARY TABLE.

Birchington, February,	*should be*	1·44	Walton-on-the-Hill, July,	*should be*	4·30
Stowell Rect., December,	,,	3·43	Nantgwillt, December,	,,	10·31
Coundon, March,	,,	2·39	Carrick-on-Shannon, Jan.,	,,	4·71
,, April,	,,	2·00			
,, November,	,,	1·84			